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The Secretary of the Navy/Chief of Naval Operations Chair in Oceanographic Sciences

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LONG-TERM GOALS

The overall long-term goals of this work are to accelerate ongoing research, to enhance the educational value of my teaching of undergraduate and graduate students, and to facilitate interactions between the academic community and researchers supporting the operating fleet.

OBJECTIVES

The general long-term research objective for this work is to advance understanding and predictive capabilities in three areas:

1) upper ocean physical, bio-optical, and biogeochemical responses to intense wind events including hurricanes and typhoons,
2) establishing relationships among optics, thermodynamics, dynamics, turbulence, and waves, and
3) the physical, bio-optical, and biogeochemical dynamics of ocean mesoscale eddies.

The overall educational objective is to contribute to the development of undergraduate and graduate students, especially those who will seek careers in the ocean sciences.

The overall transitional objective is to stimulate new interactions among academic and Navy laboratory ocean scientists who support fleet operations.

APPROACH

The approach for achieving the research goals is to utilize and build upon ongoing interdisciplinary research in the areas of optics and physics, upper ocean responses to hurricanes, and mesoscale eddies. One of the key efforts centers upon the ONR Radiance in a Dynamic Ocean (RaDyO) program described below and in more detail in another annual report. Other work utilizes data sets previously collected off Bermuda and Hawaii, which are also discussed below.

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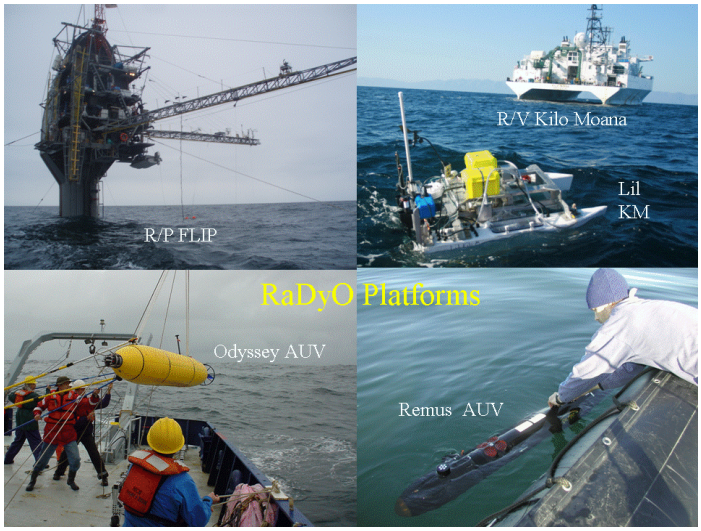
WORK COMPLETED

The Chair funding began in late September 2008. I have continued my work on the physical responses of hurricanes with a graduate student, Jennifer Sirak through Chair funding along with other members of my group and colleagues and students at JPL and UC Irvine. We are utilizing several data sets collected over the past several years from the Bermuda Testbed Mooring (BTM), located off Bermuda and near the Bermuda Atlantic Time Series (BATS) site. In addition, we are collaborating with other observationalists and modelers to better understand the relevant processes and develop improved parameterizations that are needed for better predictive capabilities. These efforts bear on various naval operations in adverse weather and sea-state conditions.

Mesoscale eddies, their detection and tracking, and their roles in biogeochemical cycling have been studied with my graduate student, Francesco Nencioli through Chair funding, collaborators at the Bermuda Institute of Ocean Sciences, VIMS, UCLA, UCSB, and other members of my group. This research involves data sets collected off Hawaii during the NSF E-FLUX experiment and off Bermuda at and near our Bermuda Testbed Mooring site. Again, interdisciplinary observations and modeling of these eddies are major thrusts of the research. Papers written on biogeochemical cycling are listed below. This research is of interest to naval operations in the presence of mesoscale features in the ocean.

I continue to be the lead PI for the ONR-sponsored Radiance in a Dynamic Ocean (RaDyO) program (Figure 1). A primary goal of RaDyO is to develop models capable of predicting the relationships among several optical properties and environmental factors as well as enabling improved models for imaging applications. In this work, we are studying the propagation of light across the air-sea interface and into and exiting the surface and upper ocean boundary layers. The first field experiment (relatively benign sea-state conditions) was conducted in the Santa Barbara Channel in September 2008 and the second field experiment (high sea-state conditions) off Hawaii was conducted in August-September 2009. Preliminary results from these experiments are described in an overview paper that is being prepared at present and are summarized in a separate ONR report on the RaDyO activity. I have led both field efforts and coordinated the organization of data, special sessions at meetings, and preparations for special journal publications for the project. A comprehensive website for RaDyO (www.opl.ucsb.edu/radyo/) has been developed and expanded. Graduate student Francesco Nencioli contributed to the RaDyO experiment by collecting optical and physical data from R/P FLIP in the Santa Barbara Channel. Graduate student Jen Sirak, assisted in the collection of data from R/V Kilo Moana for RaDyO during the Hawaii experiment. RaDyO results will be valuable for fleet operations involving visibility and imagery aspects. An overview paper for the Santa Barbara Channel RaDyO field experiment is being drafted at present Physics Today and I anticipate coordinating a collection of papers on RaDyO results for the Journal of Geophysical Research once approval by JGR has been granted.



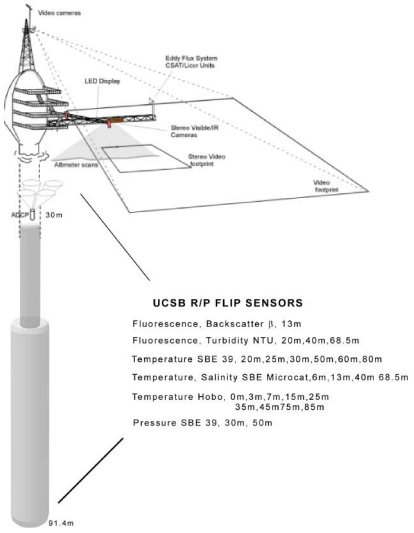


Figure 1. Left. Some of the platforms used for the RaDyO Santa Barbara Channel and Hawaii experiments, August 2008 and September 2009. Right. Schematic illustrating sampling coverage of some of the observational systems deployed from R/P FLIP.

I have continued my leadership participation in optimizing interdisciplinary observing systems, which bear on naval applications. Papers in this area include Dickey et al. (2009), Dickey (2009), and Harris eta l. (2010).

Educational efforts have included the mentoring of two graduate students, Francesco Nencioli and Jen Sirak, who have been funded through the Chair. Francesco recently completed his Ph. D. In addition, I continue to teach a large introductory oceanography class (200-300 students) and bring my research activities and experiences into the classroom.

IMPACT/APPLICATIONS

We anticipate several impacts. For example, RaDyO involves the examination of spectral time-dependent oceanic radiance distributions in relation to dynamic surface boundary layer (SBL) processes, construction of a radiance-based SBL model, validation of the model with field observations, and investigation of the feasibility of inverting the model to yield SBL light conditions. These activities bear on understanding and predicting impacts of SBL processes and ocean biogeochemistry and ecology on the underwater light field, imaging, and thus operational problems involving naval operations. The feasibility of obtaining ocean surface estimates using underwater camera data will be explored. The work in the areas of upper ocean responses to hurricanes and mesoscale eddies will be valuable for improving predictive models of fundamental oceanographic processes and are also of naval interest.

TRANSITIONS

There are no transitions yet. However, we anticipate that major transitions will develop in the form of testing and commercialization of new sensors by RaDyO collaborators (e.g., MASCOT). We expect that the RaDyO project will accelerate interdisciplinary ocean measurement technology capabilities by 1) increasing the variety of optical variables which can be measured autonomously, 2) improving the robustness and reliability of interdisciplinary sampling systems, and developing more accurate predictive models of the optical and physical environment of the ocean. In terms of the hurricane and mesoscale eddy work, transitioning of observational methodologies and predictive model parameterizations is an expected outcome.

RELATED PROJECTS

Several related projects took place in the Santa Barbara Channel during the RaDyO experiment. For example, spatial surface current data (using CODAR) were collected by Libe Washburn's UCSB group (http://www.icess.ucsb.edu/iog/realtime/index.php) and are useful for characterizing major current features and passages of sub-mesoscale features and eddies (see Nencioli et al., 2010); ship-based bio-optical data collected by the Plumes and Blooms Program (Dave Siegel, lead-PI; http://www.icess.ucsb.edu/PnB/PnB.html) facilitate interpretation of the RaDyO bio-optical data; surface hydrocarbon slicks and slick dynamics are being investigated (Ira Leifer and Jordan Clark, PIs; http://www.bubbleology.com/); and ship-based data collected by the Santa Barbara Channel Long-Term Ecological Research (LTER; Dan Reed, lead-PI; with focus on land-ocean margin; http://sbc.lternet.edu/) program. Mark Moline of Cal Poly collected physical and optical data in conjunction with both the Santa Barbara Channel and Hawaii RaDyO field experiments. Satellite sea surface temperature and ocean color data were collected by our group, and Ben Holt (Jet Propulsion Laboratory, JPL) collected synthetic aperture radar (SAR) data for the Santa Barbara Channel experiment. These remote sensing data sets along with others provide spatial context. By combining and synthesizing these data sets with ours, we are able to describe and quantify the three-dimensional evolution of several key water quality parameters on time scales of a day to the interannual. Modelers working with us on these data sets include Charles Jones (UCSB), Leila Carvalho (UCSB), Charles Dong (UCLA), and Yi Chao (JPL).

There are several collaborative efforts that we have already in place for the hurricane/typhoon and mesoscale eddy research planned here. For example, we have been working with Maureen Conte

(BIOS) on color changes in the wakes of hurricanes. Yi Chao (UCLA) and Mai Wei (UC Irvine) plan to do model simulations of our hurricane data sets and one of my graduate students, Jen Sirak, is focusing her efforts in this area. Another of my graduate students, Francesco Nencioli, worked with Charles Dong (UCLA) on eddy tracking and interdisciplinary mesoscale modeling. During the first year, I contributed a paper to the SPIE meeting in Orlando and interacted with several of the individuals mentioned above.

PUBLICATIONS

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HONORS/AWARDS/PRIZES

Professor Dickey was named Outstanding Professor by University of California Santa Barbara Residence Hall Association and Office of Residential Life (2009).